SCIENCE IN AMERICA

THE following appropriations by the U.S. Congress were made at the session of 1869-70 for the ensuing year, July 1, 1870, to June 30, 1871, in aid of Science, Literature, &c.

It should be observed that the undermentioned appropriations are those of the General Government, and not those of the separate States, which, in the aggregate, would far exceed the amount here presented.

	$	$
Museums.		
National Museum in charge of Smithsonian Institution	20,000	
Army Medical Museum	5,000	
Agricultural Departmt. Museum	8,000	
		33,000
Botanic Gardens and Greenhouses.		
Of the U.S. Capitol	35,996	
„ „ President's House	2,500	
„ „ Agricultural Department	38,200	
		76,696
Agriculture.		
Department of Agriculture, Miscellaneous Expenses		138,070
[To this is to be added, items already given,—		
Botanic Garden and Living Plants	38,200	
Museum	8,000	
Library	3,800—50,000	
or an aggregate of $188,070.]		
Astronomy and Meteorology.		
Observations of Eclipse, Dec. 1870, under Coast Survey	29,000	
U.S. Nautical Almanac	20,000	
National Observatory	19,800	
New Telescope for National Observatory	50,000	
Telegraphic Notices of Storms	50,000	
		168,800
Surveys, &c.		
U.S. Coast Survey	703,000	
Survey of Lakes	150,000	
„ Nicaragua and Tehauntepec Ship Canals	30,000	
Military Surveys west of Mississippi	100,000	
Prof. Powell's Survey of Colorado of West	12,000	
Polar Explorations	50,000	
Dr. Hayden's Geological Survey	25,000	
Statistics of Mines and Mining	10,000	
		1,080,000
Light-house Establishments		1,431,207
Libraries.		
Library of Congress	36,220	
„ of Medical Department, U.S.A.	3,000	
„ of Agricultural Department	3,800	
		43,020
Education.		
U.S. Department of Education	14,500	
Wilberforce and Lincoln Universities	37,000	
		51,500
Benevolent Objects.		
Life-boat Service on the Coast	48.883	
Government Hospital for Insane	149 980	
Columbia Institution for Deaf and Dumb	40,775	
Columbia Hospital for Women	18,000	
National Association for Destitute Coloured Women, D.C.	10,000	
National Soldiers' and Sailors' Home, D.C.	15,000	
Care of 60 transient Paupers	12,000	
		234,635
Total		$ 3,316,928

THE INFLUENCE OF INTENSE COLD ON STEEL AND IRON

THERE has recently been a most interesting discussion at the Literary and Philosophical Society, Manchester, on the above subject, the result of which seems to be that we must at once give up the idea that such accidents as the one, for instance, near Hatfield, are due to anything beyond the control of the Railway Companies concerned.

The paper which gave rise to the discussion was by Mr. Brockbank, who detailed many experiments, and ended by stating his opinion that iron does become much weaker, both in its cast and wrought state, under the influence of low temperature; but Mr. Brockbank's paper was immediately followed by others by Sir W. Fairbairn, Dr. Joule, and Mr. Spence, which at once put an entirely new complexion on the matter.

As Dr. Joule's results are the most to the point we may take them first. He says:—

"As is usual in a severe frost, we have recently heard of many severe accidents consequent upon the fracture of the tires of the wheels of railway carriages. The common-sense explanation of these accidents is, that the ground being harder than usual, the metal with which it is brought into contact is more severely tried than in ordinary circumstances. In order apparently to excuse certain Railway Companies, a pretence has been set up that iron and steel become brittle at a low temperature. This pretence, although put forth in defiance, not only of all we know of the properties of materials, but also of the experience of everyday life, has yet obtained the credence of so many people that I thought it would be useful to make the following simple experiments:—

"1st. A freezing mixture of salt and snow was placed on a table. Wires of steel and of iron were stretched so that a part of them was in contact with the freezing mixture, and another part out of it. In every case I tried the wire broke outside of the mixture, showing that it was weaker at 50° F. than at about 12° F.

"2nd. I took twelve darning needles of good quality, 3in. long, $\frac{1}{24}$in. thick. The ends of these were placed against steel props, $2\frac{1}{4}$in. asunder. In making an experiment, a wire was fastened to the middle of a needle, the other end being attached to a spring weighing-machine. This was then pulled until the needle gave way. Six of the needles, taken at random, were tried at a temperature of 55° F, and the remaining six in a freezing mixture which brought down their temperature to 12° F. The results were as follow:—

Warm Needles.	Cold Needles.
64 oz. broke	55 oz. broke
65 „ „	64 „ „
55 „ „	72 „ „
62 „ „	60 „ bent
44 „ „	68 „ broke
60 „ bent	40 „ „
Average $58\frac{1}{3}$	Average $59\frac{5}{6}$

"I did not notice any perceptible difference in the perfection of elasticity in the two sets of needles. The result, as far as it goes, is in favour of the cold metal.

"3rd. The above are doubtless decisive of the question at issue. But as it might be alleged that the violence to which a railway wheel is subjected is more akin to a blow than a steady pull; and as, moreover, the pretended brittleness is attributed more to cast-iron than any other description of the metal, I have made yet another kind of experiment. I got a quantity of cast-iron garden nails, an inch and a quarter long and ⅛in. thick in the middle. These I weighed, and selected such as were nearly of the same weight. I then arranged matters so that by removing a prop I could cause the blunt edge of a steel chisel, weighted to 4lb. 2oz., to fall from a given height upon the middle of the nail as it was supported from each end, $1\frac{1}{16}$in. asunder. In order to secure the absolute fairness of the trials the nails were taken at random and an experiment with a cold nail was always alternated with one at the ordinary temperature. The nails to be cooled were placed in a mixture of salt and snow, from which they were removed and struck with the hammer in less than 5^s."

The collective result of the experiments, the details of which need not be given, was that 21 cold nails broke and 20 warm ones.

Dr. Joule adds, "The experiments of Lavoisier and Laplace, of Smeaton, of Dulong and Petit, and of Troughton, conspire in giving a less expansion by heat to steel than iron, especially if the former is in an untempered state. Such specimens of steel-wire and of watch-spring as I possess expand less than iron. But this, as Sir W. Fairbairn observed to me, would in certain limits have the effect of strengthening rather than of weakening an iron wheel with a tire of steel.

"The general conclusion is this: Frost does *not* make either iron (cast or wrought) or steel brittle, and that accidents arise from the neglect of the companies to submit wheels, axles, and all other parts of their rolling stock to a practical and sufficient test before using them."

Mr. Spence in his experiments decided on having some lengths of cast-iron made of a uniform thickness of ½in. square, from the same metal and the same mould.

He writes:—"Two of the four castings I got seemed to be good ones, and I got the surface taken off, and made them as regular a thickness as was practicable.

"I then fixed two knife-edged wedges upon the surface of a plank, at exactly nine inches distance from each other, with an opening in the plank in the intervening space, the bar being laid across the wedges, a knife-edged hook was hung in the middle of the suspended piece of the bar, to the hook was hung a large scale on which to place weights.

"The bar was tried first at a temperature of 60° F.; to find the breaking weight I placed 56lb. weights one after another on the scale, and when the ninth was put on the bar snapped. This was the only unsatisfactory experiment, as 14 or 28lb. might have done it, but I include it among the others. I now adopted another precaution, by placing the one end of the plank on a fixed point and the other end on to a screw-jack, by raising which I could, without any vibration, bring the weight to bear upon the bar. By this means, small weights up to 7lb. could be put on while hanging, but when these had to be taken off and a large weight put on, the scale was lowered to the rest, and again raised after the change was made. I may here state that a curious circumstance occurred twice, which seems to indicate that mere raising of the weight, without the slightest apparent vibration, was equal in effect to an additional weight. 3¾cwts. were on the scale, a 14lb. weight was added, then 7lb., then 4lb, 2lb., 1lb., and 1lb., making 4cwts. and 1lb. This was allowed to act for from one to two minutes, and then lowered to take off the small weights, and replaced by a 56lb., intending to add small weights when suspended, raised so imperceptibly by the screw, that the only way of ascertaining that it was suspended was by looking under the scale to see that it was clear of the rest. As soon as it was half-an-inch clear it snapped, thus breaking at once with one pound less than it resisted for nearly two minutes.

"Six experiments were carefully conducted at 60° F., the parts of the bars being selected so as to give to each set of experiments similar portions of both bars; the results are marked on the pieces. My assistant now prepared a refrigerating mixture which stood at zero, and the bars were immersed for some time in this, and we prepared for the breaking trials to be made as quickly as could be, consistently with accuracy, and to secure the low temperature each bar on being placed in the machine had its surface at top covered with the freezing mixture. *The bars at zero broke with more regularity than at* 60°, *but instead of the results confirming the general impression as to cold rendering iron more brittle, they are calculated to substantiate an exactly opposite idea, namely, that reduction of temperature,* cæteris paribus, *increases the strength of cast iron.* The only doubtful experiment of the whole twelve is the first, and as it stands much the highest, the probability is that it should be lower; yet, even taking it as it stands, the average of the six experiments at 60° F. gives 4cwt. 4lb. as the breaking weight of the bar at that temperature, while the average of the six experiments at zero gives 4cwt. 20lb. as the breaking weight of the bar at zero, being an increase of strength from the reduction of temperature equal to 3·5 per cent."

Sir W. Fairbairn's evidence is of great importance, for he not only gives facts showing that frost does not affect the tires, but he states the real cause of such accidents as are generally attributed to the frost.

He states:—"It has been asserted in evidence given at the coroner's inquest on the Hatfield accident, that the breaking of the steel tire was occasioned by the intensity of the frost, which is supposed to render the metal brittle, and of which this particular tire was composed. This is the opinion of most persons, but judging from my own experience such is not the fact, and provided we are to depend on actual experiment, it would appear that temperature has little or nothing to do with it. Some years since I endeavoured to settle this question by a long and careful series of experiments on wrought-iron, from which it was proved that the resistance to a tensile chain was as great at the temperature of zero as it was at 60° or upwards, until it attained a scarcely visible red heat. To show that this was the case, and taking, for example, the experiments at 60°, it will be found that the mean breaking weight, in tons, per square inch, was in the ratio of 19·930 to 21·879, or as 1 : 1·098 in favour of the specimens broken at the temperature of zero. The generally received opinion is, however, against these facts, and it is roundly asserted that the strength of iron and steel is greatly reduced in strength at a temperature below freezing. The contrary was proved to be the case in wrought-iron plates, and assuming that steel follows the same law, it appears evident that we must look for some other cause than change of temperature for the late fracture of the tire on the wheel of the break-van of the Great Northern Railway. . . . The immense number of purposes to which both iron and steel are applied, and the changes of temperature to which they are exposed, renders the inquiry not only interesting in a scientific point of view, but absolutely necessary to a knowledge of their security under the various influences of those changes; and when it is known that most of our metal constructions are exposed to a range of temperatures varying from the extreme cold of winter to the intense heat of summer, it is assuredly desirable to ascertain the effects produced by those causes on material from which we derive so many benefits, and on the security of which the safety of the public frequently depends. It was for these reasons that the experiments in question were undertaken; and the summary of results are sufficiently conclusive to show that changes of temperature are not always the cause of failure, as that which occurred near Hatfield on the Great Northern Railway. That such is the fact, I may adduce several accidents of broken tires all of which occurred during the spring and summer months when the temperature was high. One of them occurred on the Lancashire and Yorkshire Railway in the summer of last year when the temperature was 50° to 60° above freezing. I could enumerate others in which the winter frosts had nothing to do with the fractures which ensued."

After referring to some other experiments, Sir W. Fairbairn proceeded : "The danger arising from broken tires does not, according to my opinion, arise so much from changes of temperature *as from the practice of heating them to a dull red heat, and shrinking them on to the rim of the wheels*. This, I believe, is the general practice, and the unequal, and in some cases, the severe strains to which they are subject, has a direct tendency to break the tires. To show how easily this may be effected, let us suppose that a tire, two feet six inches or three feet diameter, is shrunk on to a wheel one-tenth of an inch larger than the tire, it then follows that the tire in cooling must be elongated to that extent, with a strain equivalent to the force of the shrinkage, and calculated to produce that amount of molecular disturbance. It may be more or it may be less, but supposing the strain to be one-half or three-fourths of that which would break the tire, it then follows that the constant action of its irregular motion on the rails must ultimately lead to fracture.* I am not surprised that this should be the case, as most, if not the whole, of railway tires, excepting those on engines and tenders, are not turned, but selected by hand, heated and shrunk upon the wheels with every degree of tension, as suits the convenience of the workman. So long as this process is pursued the public will be exposed to the risk of broken tires. What is required in this description of manufacture is, that the rim of the wheel and the inside of the tire should be *turned to a standard gauge*, accurately calculated to give the required amount of tightness with a larger margin of strength, and this done we should attain greatly increased security to the public, and a great saving in wear and tear—to say nothing of the large sums expended by companies in the shape of compensation for injuries and loss of life."

Here, then, is another potential triumph for more scientific accuracy and more hope for travellers.

SCIENTIFIC SERIALS

Poggendorff's Annalen der Physik und Chemie, 1870, *No.* 9.—The contents of this number are :—(1.) "Calorimetric Researches," by R. Bunsen. In the first part of this paper Prof. Bunsen describes the construction and method of using a new calorimeter, in which quantities of heat are measured by the amount of ice at 0° which they are capable of converting into water at the same temperature. The quantity of ice melted is in its turn indicated by the resulting diminution of volume, as shown by the movement of a mercury-column in a graduated capillary tube communicating with the vessel in which the ice is contained. In order to convert the results obtained by this method into absolute heat-units, it is necessary, either that the motion of the mercury-column produced by a known quantity of heat should be ascertained, or that the specific gravity of ice at 0° and its latent heat of fusion should be known. The first of these quantities was found by observing the effect produced by a given weight of boiling water, and the second by a process which may be described as consisting in the application of the principle of the weight-thermometer to measure the change of volume which water undergoes on freezing. From these data the third of the quantities mentioned, or the latent heat of fusion of ice, is readily calculated. Of the numerical results, given in the paper, we will quote only the following :—

Specific gravity of ice at 0° C	0·91674
Latent heat of fusion of ice	80·025
Specific heat of indium	0·0570
Specific heat of calcium	0·1704

One special advantage of this method of calorimetry is that it allows good results to be obtained with very small quantities of material ; for instance, for specific heat determinations, from 0·3 gramme to, at the most, 4 grammes is sufficient. (2.) "On the relations between the crystalline form and chemical constitution of some organic compounds," by P. Groth. (3.) "Experimental and theoretical investigation of the figures of Equilibrium of a liquid mass without weight" (Eighth series), by J. Plateau. A translation of this paper, which relates to the conditions of the ready production and of the persistency of liquid films, to the superficial tension of liquids, and to their superficial viscosity, was printed in the *Philosophical Magazine* vol. xxxviii. p. 445 [1869.] (4.) "On the Absorption of Light," by Paul Glan. Among other results, the author finds that the absorbing power of a substance, when it is employed in solutions of different degrees of concentration, increases in a greater ratio than the concentration ; also, that the absorbing power of a body in solution is affected by the nature of the medium in which it is dissolved. The experimental results are followed by a mathematical discussion of the mechanism of the absorption of light. (5.) "Additional researches into the behaviour of Vapours in relation to the Laws of Mariotte and Gay-Lussac," by Dr. Hermann Herwig. This paper has reference to an earlier one published in vol. cxxxvii. of *Poggendorff's Annalen*. The author finds that, when the pressure upon a vapour at a given temperature is diminished so far that the vapour obeys Mariotte's law, that is to say, so far that the product of the pressure into the corresponding volume becomes constant, this product bears to the similar product, when the pressure is great enough to cause the vapour to be saturated at the same temperature, a constant ratio which is proportional to the square root of the absolute temperature. In the present paper it is shown that ethylic bromide and carbonic sulphide conform to this law. (6.) "Some analogous Theorems in Photometry and in the Laws of Attraction," by Wilhelm von Bezold. The mathematical law of the inverse square of the distance applying equally to the illumination produced by a luminous point, and to the force exerted by an attracting particle, it follows that the mathematical expressions by which photometrical relations are expressed, will also admit of an interpretation in relation to the action of attracting particles. In this paper the double interpretation of the same formula is pointed out in several important cases. For example :—The author shows that the photometrical analogue of an equipotential surface drawn about several attracting particles, is a surface so placed, relatively to luminous points, whose luminosity is proportional to the masses of the particles, that the illumination of each element of the surface is greater than that of any other element passing through the same point. (7.) "On the Luminosity of Phosphorus," by W. Müller. The author finds that phosphorus vapour is not luminous in the absence of free oxygen ; that it is not luminous at ordinary atmospheric temperatures when in contact with pure oxygen of atmospheric pressure, but that it becomes luminous, and at the same time absorbs oxygen, when the pressure is diminished to a certain amount, depending on the temperature, the necessary reduction of pressure being greater when the temperature is lower ; and that phosphorus which has been for some time in contact with certain vapours, (notably hydrocarbons), is deprived by them of the property of becoming luminous on the admission of air, although air, mixed with the same vapours, is not thereby deprived of the power of exciting (temporary) luminosity in phosphorus. (8.) "On the Superoxides that can be prepared by Electrolysis," by W. Wernicke. (9.) "On a mechanical theorem applicable to Heat," by R. Clausius. (10) "On the Spectra of negative Electrodes, and of long-used Geissler's Tubes," by Prof. Edm. Reitlinger and Prof. Moriz Kuhn. (11.) "On the Meissner Lignite modified by contact with Basalt," by Dr. A. von Lasaulx. (12.) "On the analysis of Silicates," by E. Ludwig. Refers chiefly to the precautions required for the accurate separation of silica and alumina. (13.) "On the absorption-spectrum of liquid peroxide of Nitrogen," by August Kundt. On comparing the absorption-spectra of liquid and gaseous peroxide of nitrogen, the author found that the ill-defined black bands in the spectrum of the former coincided in position with strongly-marked groups of lines in the spectrum of the latter. (14.) "On the work done by Gases in Motion, or remarks on the paper so entitled," by Dr. A. Kurz. This is a reply to a criticism by Dr. Boltzman (noticed in NATURE, vol. ii. p. 364) of a previous paper by the author.

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* From long-continued action under strain, it has been proved that it is only a question of time when rupture takes place, as repeated increased and diminished changes with the same load ultimately leads to fracture.